High-Strain-Rate, Superplastic Metal Forming

Low-cost, net-shape, complex structural components in a single operation

Superplasticity is the ability of certain materials to undergo extraordinary tensile deformation (usually more than 300%) without fracturing. Materials that have demonstrated superplasticity include aluminum, titanium, nickel, steels, and even some ceramics. This large tensile elongation can be used effectively to form net-shape, complex structures. Superplastic forming offers many advantages, including

- Elimination of unnecessary joints and rivets
- Reduction of subsequent machining
- Minimization of materials waste.

An integrated aluminum structure, for example, traditionally manufactured by welding four pieces of metal, can now be manufactured in a single operation through superplastic forming.

Higher strain rates for practical processing

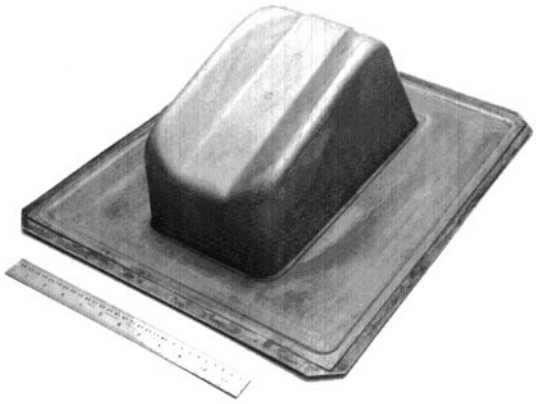
Until recently, superplastic forming has only been available at relatively low strain rates, typically about 1% per minute. At this strain rate, about one hour is needed to form an advanced structural component—too long to be economically effective. Superplasticity at higher strain rates, however, can be expected to stimulate broad commercial interest in superplastic forming. A strain rate higher than 100% per minute is considered economically practical. Such a strain rate would allow the forming of relatively complex structures in less than 3 minutes, including set-up time.

APPLICATIONS

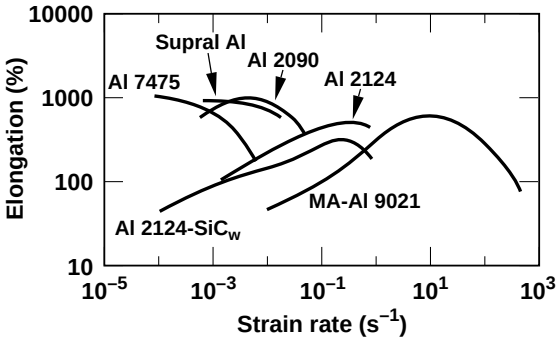
- *Bulk- and sheet-metal forming for automotive and transportation industries*
- *Forming of aircraft frames and skins*
- *Diaphragm forming of plastics*

Superplastic forming for many materials

At LLNL, we recently discovered that superplasticity can exist at considerably higher strain rates than 100% per minute. We have observed this high-strain-rate superplasticity in metal-matrix composites, powder metallurgy alloys, and certain conventionally produced metallic alloys. Although our observations are mainly of aluminum alloys, in principle the phenomenon should not be limited by materials. Under appropriate processing conditions, high-strain-rate superplastic forming technology can be used to make complex structural parts from any metal, both in the bulk and sheet forms.



A superplastically formed Al-Li alloy component.



Superplastic behavior as a function of strain rate.

Availability: This processing technique is available now. We invite the collaboration of industrial partners with whom we can work to develop the technique for specific materials and applications.

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